EVIDENCE FOR THE EXISTENCE OF ASSOCIATED MESONS IN COSMIC-RAY SHOWERS*

By M. S. SINHA, M.Sc., and R. L. SENGUPTA, M.Sc., Ph.D.

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ABSTRACT Evidence has been obtained of the existence of associated mesons in cosmic-ray showers with a Counter-controlled Wilson Chamber arranged so as to record showers only. A 2.2 cm lead plate was placed inside the chamber and the nature of the particles photographed has been ascertained from the fact whether they have been absorbed or multiplied by this lead plate or have emerged out of it without producing secondaries

Investigations of Janossy and Ingleby,[1] Wataghin, de Souza Santos, etc,[2] with coincidence counters interposing large thicknesses of lead absorbers have indicated the existence of showers of penetrating particles. Cloud chamber evidence of associated penetrating particles have also been obtained by Braddick and Hensby[3] working under 30 metres of London clay and by Herzog and Bostick[4] in the substratosphere. The present work is an attempt to take a large number of photographs of penetrating cosmic-ray showers to furnish an adequate data for a complete investigation of their behaviour. We have been using a cloud chamber operated by a five-fold coincidence arrangement shown in Figure 1. The arrangement is practically a three-fold coincidence one,

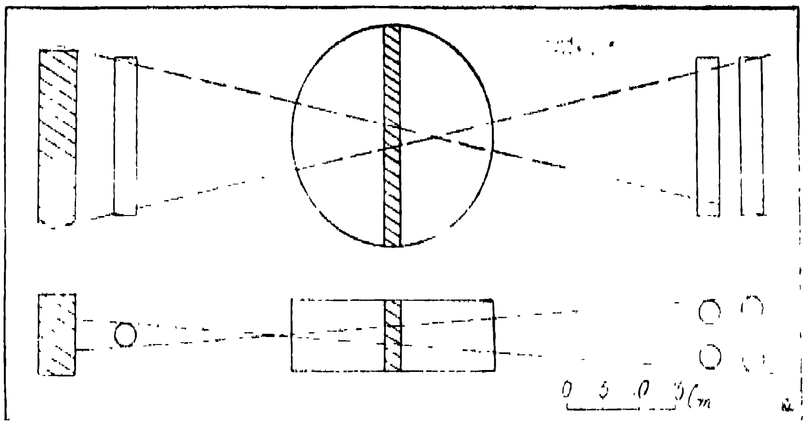

Fig. 1

the extreme bottom counters being used to define the geometry more precisely and to make the number of accidentals very small.

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A lead plate of 2.2 cm. thickness has been inserted in the chamber. The nature of a particle traversing the lead plate can be ascertained from the rate of production of secondaries during the traversal. For an electron, for example, of energy 10^9 ev. it is very unlikely that it will emerge out of it without being accompanied by secondaries, whereas for a meson of the same energy the probability of emerging with a secondary is very small.

The preliminary experiment was carried out without any lead plate above the top counter and the photographs obtained were mostly of cascade showers, a typical and interesting case of which is shown in Figure 2, which shows both absorption and multiplication of an extensive air shower in the lead plate placed inside the chamber.

With the arrangement given in Figure 1, *i.e.*, with the top absorber 5 cm. thick, about thirty photographs have been taken, of which Figure 3 is an interesting case.

In Figure 4, we find two penetrating particles with a few electrons associated with them. The slight convergence between the tracks (*a*) and (*b*) is apparently due to scattering of the particles in the top lead absorber. The track (*a*) can be assigned to that of a meson as no secondary has been produced in the traversal of 2.2 cm. of lead. Although the particle (*b*) has emerged from the lead plate with a secondary it is very unlikely that the incident particle is an electron due to the following reasons :—

(1) The magnitude of scattering suffered by the incident particle sets a lower limit to its energy which is 10^9 ev.

(2) The probability that an electron of this energy will penetrate 2.2 cm. lead plate with a single secondary is of the order of 10^{-4}.

We therefore consider it to be the case of an associated meson pair accompanied with a few soft electrons which are observed on the photograph along with the penetrating particles.

Some photographs have also been taken by changing the thickness of the top absorber to 10 cms. The coincidence rate has not appreciably changed which is in agreement with Janossy and Ingleby's observation on penetrating showers where they find associated penetrating particles in groups of different numbers occurring almost with the same frequency even when the thickness of the absorber is gradually increased. With 5 cm. thick top absorber the majority of the photographs were of cascade showers either in the absorber or in the lead plate inside the chamber. The yield of penetrating showers has apparently increased on changing the thickness of the top absorber to 10 cm. Any attempt at interpretation regarding this is however premature until more data is available to make the indication statistically significant.

Two interesting cases with the top absorber 10 cms. are shown in Figures 4 and 5. Figure 4 shows clearly a pair of penetrating particles. No magnetic

Fig. 2.

Fig. 3.

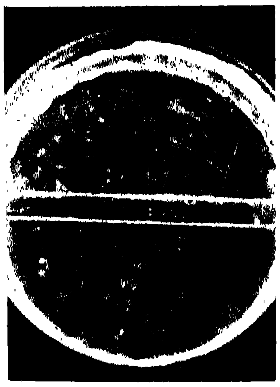

Fig. 4

Fig. 5.

field has been applied so that the slight bending of the tracks is due to convection currents set up in the chamber. The pair appears to be generated within a few centimetres from the wall of the chamber and can be looked upon as an air shower. A similar photograph has been reported by Braddick and Hensby.[3]

Figure 5 is the most important of the series of photographs. It shows at least four penetrating mesons (shown by arrow heads) with a large number of fairly energetic electrons, one of which has produced a cascade shower in the lead plate. Janossy and Ingleby[1] have also observed, by means of counters, showers containing penetrating particles up to eight in number. From the geometry of the tracks it is evident that the lead absorber on the top cannot be the source of generation of the particles. We therefore presume that the rays constitute an air shower consisting of electrons and mesons in conformity with the general view on the structure of the extended air showers.

In conclusion, the authors wish to express their gratefulness to Dr. D. M. Bose, M.A., Ph.D., for his advice and encouragement throughout the work. The experiment is in progress and a detailed account of the complete work will be published later.

THE BOSE INSTITUTE,
UPPER CIRCULAR ROAD,
CALCUTTA

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